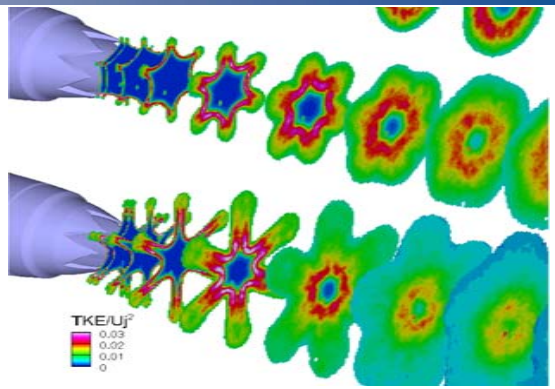
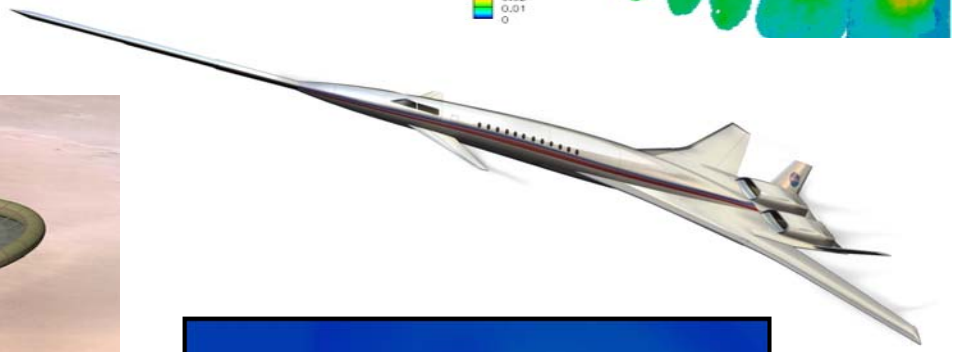
Supersonics Project Overview

Fundamental Aeronautics Annual Meeting

Atlanta, Georgia

October 7, 2008

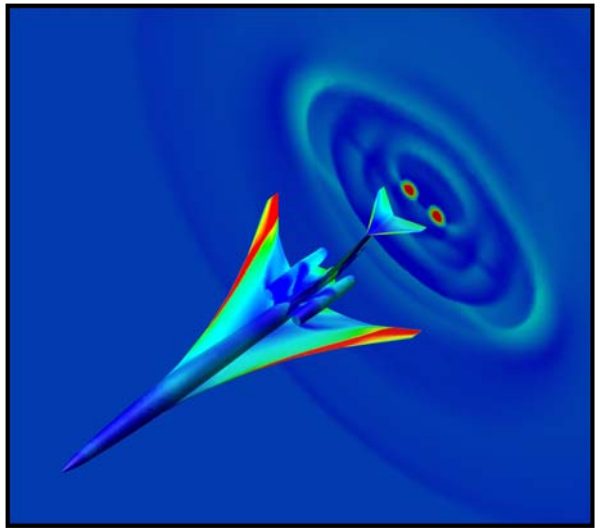




PI: Peter Coen

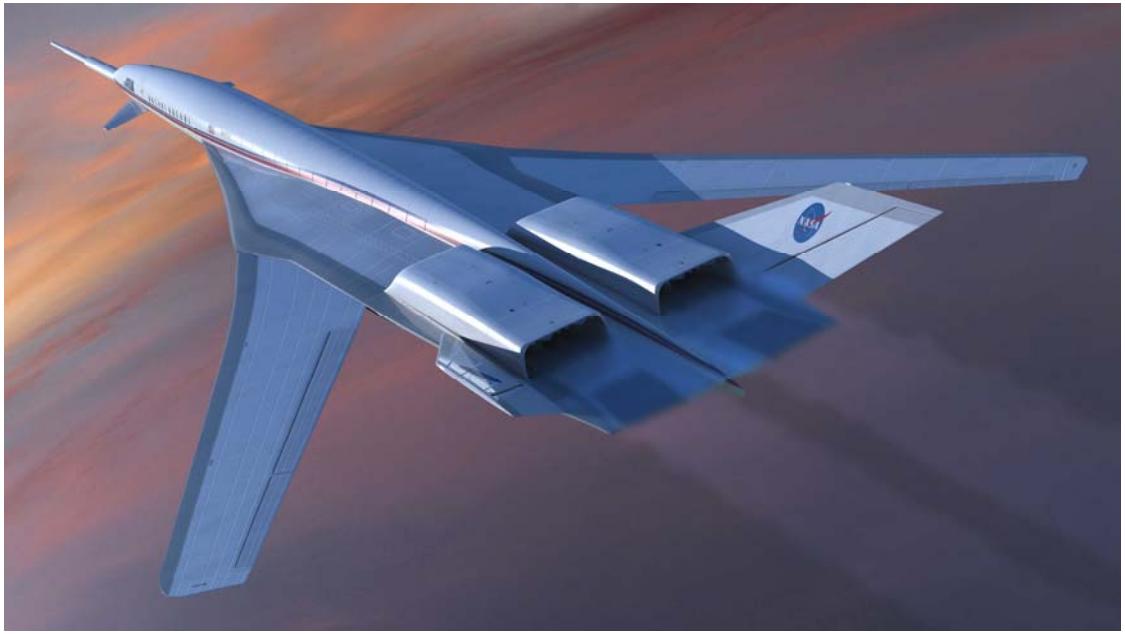
PS: Lou Povinelli

PM: Kaz Civinskas



Fundamental Aeronautics Supersonic Project

Project Goal: Tool and technology development for the broad spectrum of supersonic flight.



Supersonic Cruise Aircraft

Eliminate the efficiency, environmental and performance barriers to practical supersonic cruise vehicles

High Mass Planetary Entry Systems

Address the critical supersonic deceleration phase of future large payload Exploration and Science Missions

Supersonics Project Technical Challenges

The Supersonics technical challenge areas are designed to break the traditional discipline "stovepipes" and foster innovative solutions "at the seams" between disciplines

- Efficiency Challenges - 30 % Improvement over HSR
  - Supersonic Cruise Efficiency
  - Light Weight and Durability at High Temperature
- Environmental Challenges - No greater impact than subsonic fleet
  - Airport Noise: Acceptable levels without weight or performance penalty
  - Sonic Boom: Propagation, prediction and design
  - High Altitude Emissions: Emissions impact must be minimized or eliminated
- Performance Challenges - Safe and comfortable flight for crew and passengers
  - Aero-Propulso-Servo-Elastic (APSE) Analysis and Design: Controlling flutter, gust, and maneuver loads in a manner that is synergistic with the vehicle structural design
- Entry Descent and Landing Challenges
  - Supersonic Entry Deceleration: Develop tools and technologies to support the design and validation of exploration systems capable of landing payloads in the 30 metric ton class
- System Integration, MDAO Challenges
  - Understanding and exploiting the interactions of all these supersonic technology challenges is the key to the creation of practical designs
- Integration of Supersonic Aircraft in NextGen System
  - Determine the characteristics for an airspace that enables supersonic aircraft to utilize their full capabilities

Supersonics Project Technical Elements - Part 1

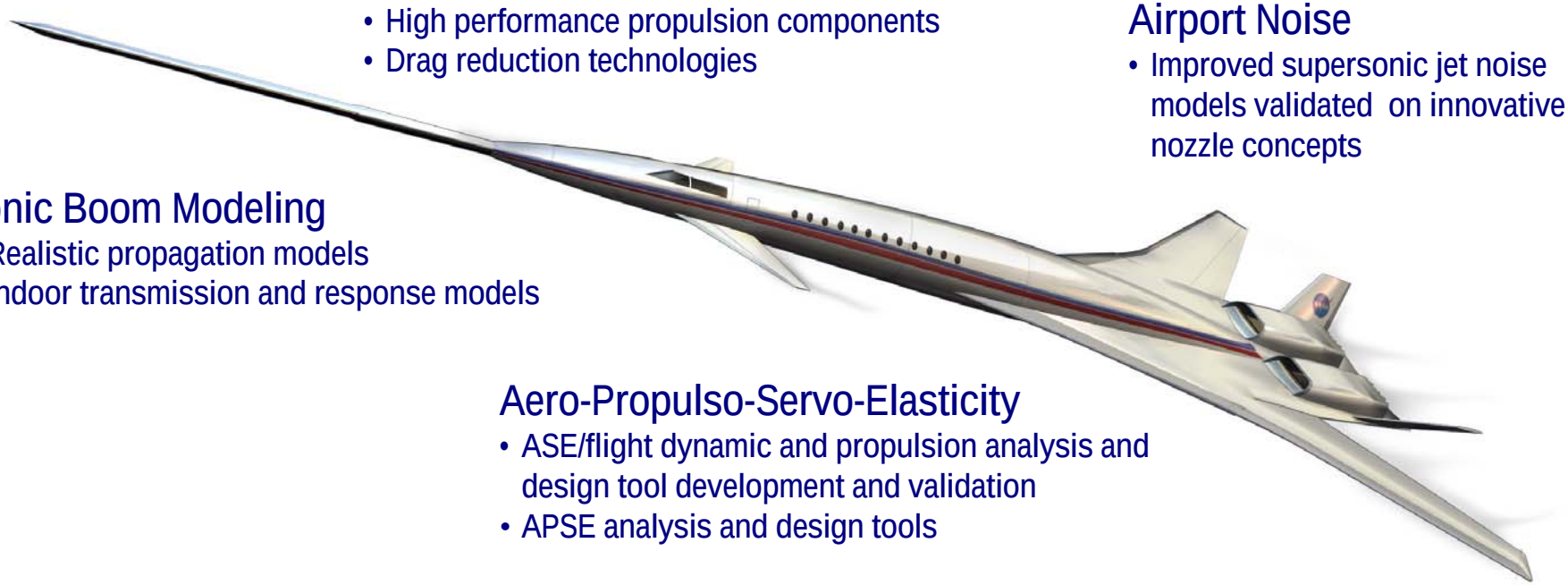
Deliver Knowledge, Capabilities, and Technologies Addressing Supersonics Challenges

Cruise Efficiency

- Tools and technologies for integrated propulsion and vehicle systems level analysis and design
- High performance propulsion components
- Drag reduction technologies

Airport Noise

- Improved supersonic jet noise models validated on innovative nozzle concepts



Sonic Boom Modeling

- Realistic propagation models
- Indoor transmission and response models

Aero-Propulso-Servo-Elasticity

- ASE/flight dynamic and propulsion analysis and design tool development and validation
- APSE analysis and design tools

Light Weight and Durability at High Temperature

- Materials, test and analysis methods for airframe and engine efficiency, durability and damage tolerance

High Altitude Emissions

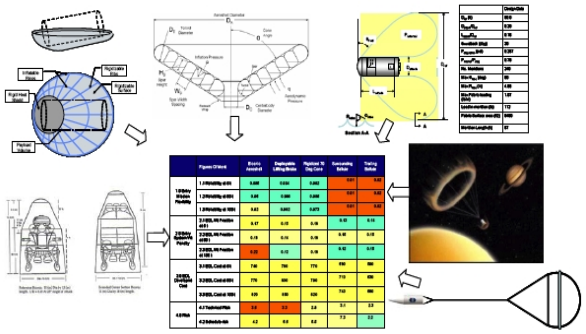
- Improved prediction tools
- Low emissions combustors

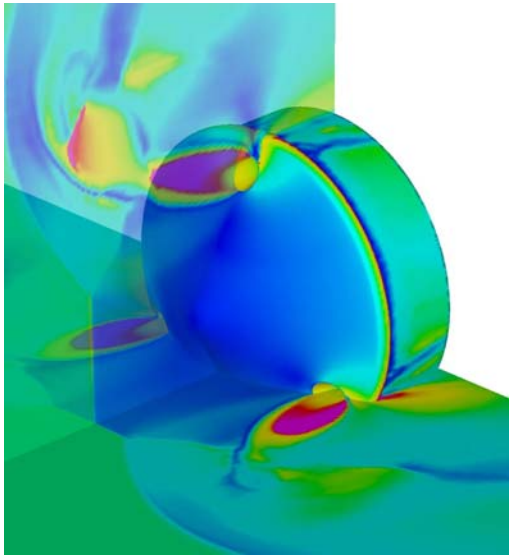
Supersonics Project Technical Elements - Part 2

In partnership with the Hypersonics Project, Lay the Groundwork for Future High Mass Entry Systems

Innovative Concepts

- Integrated elements
- System-level trade studies



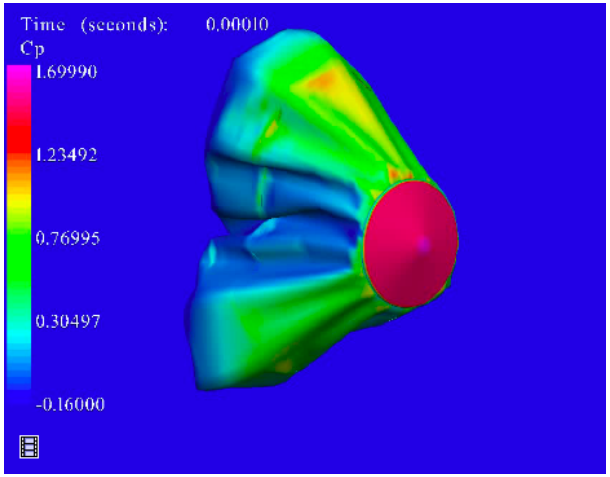


Fluid Dynamics

- Highly unsteady flow
- Turbulence
- Performance

Fluid-Structures Interaction

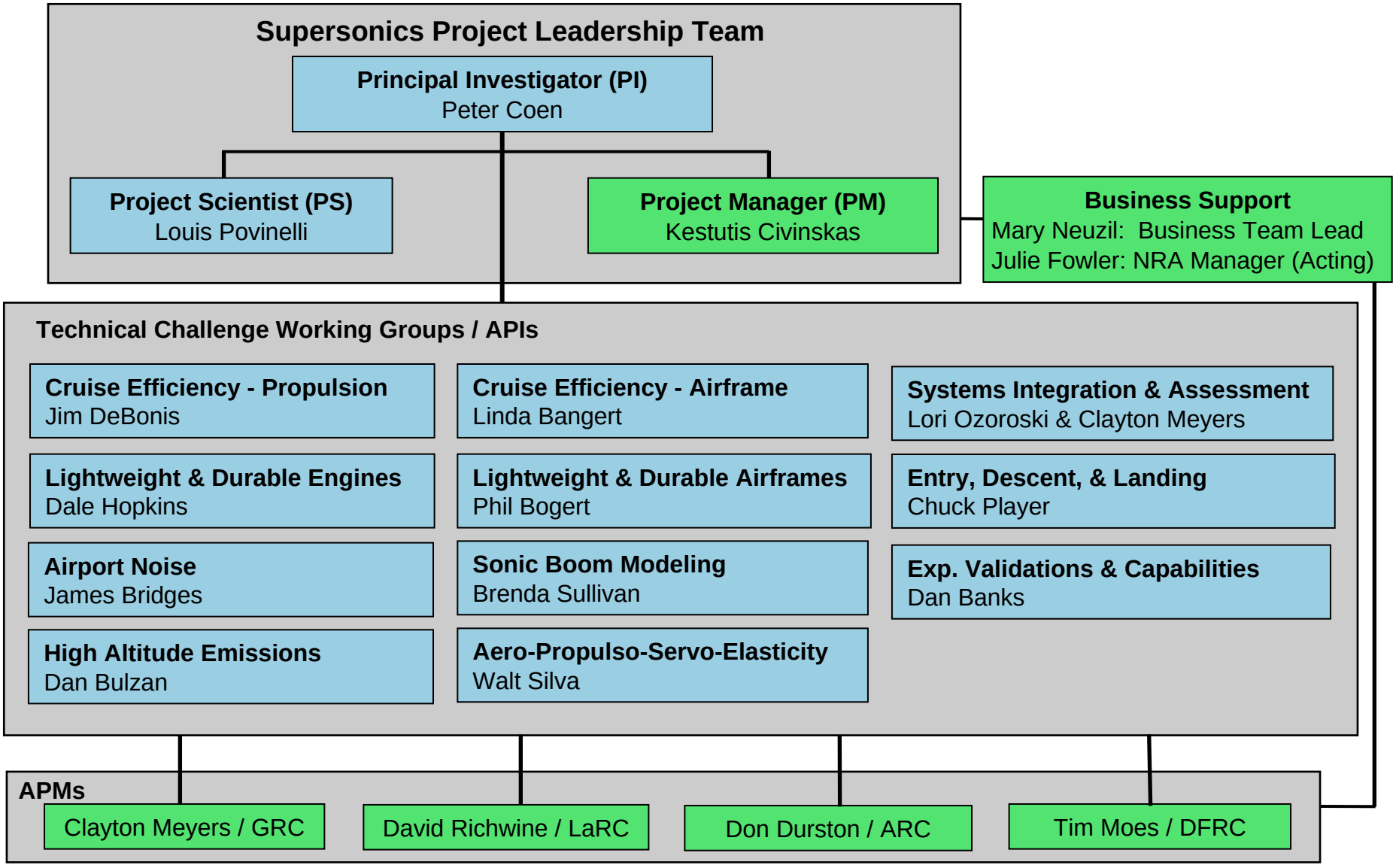
- Simulation tools for design
- Flexible membrane structures
- High-speed deployment



Propulsive Deceleration

- Analytical tools and methods
- Reaction control systems

Supersonics Project - Organization & Key Personnel



Project Contact Information

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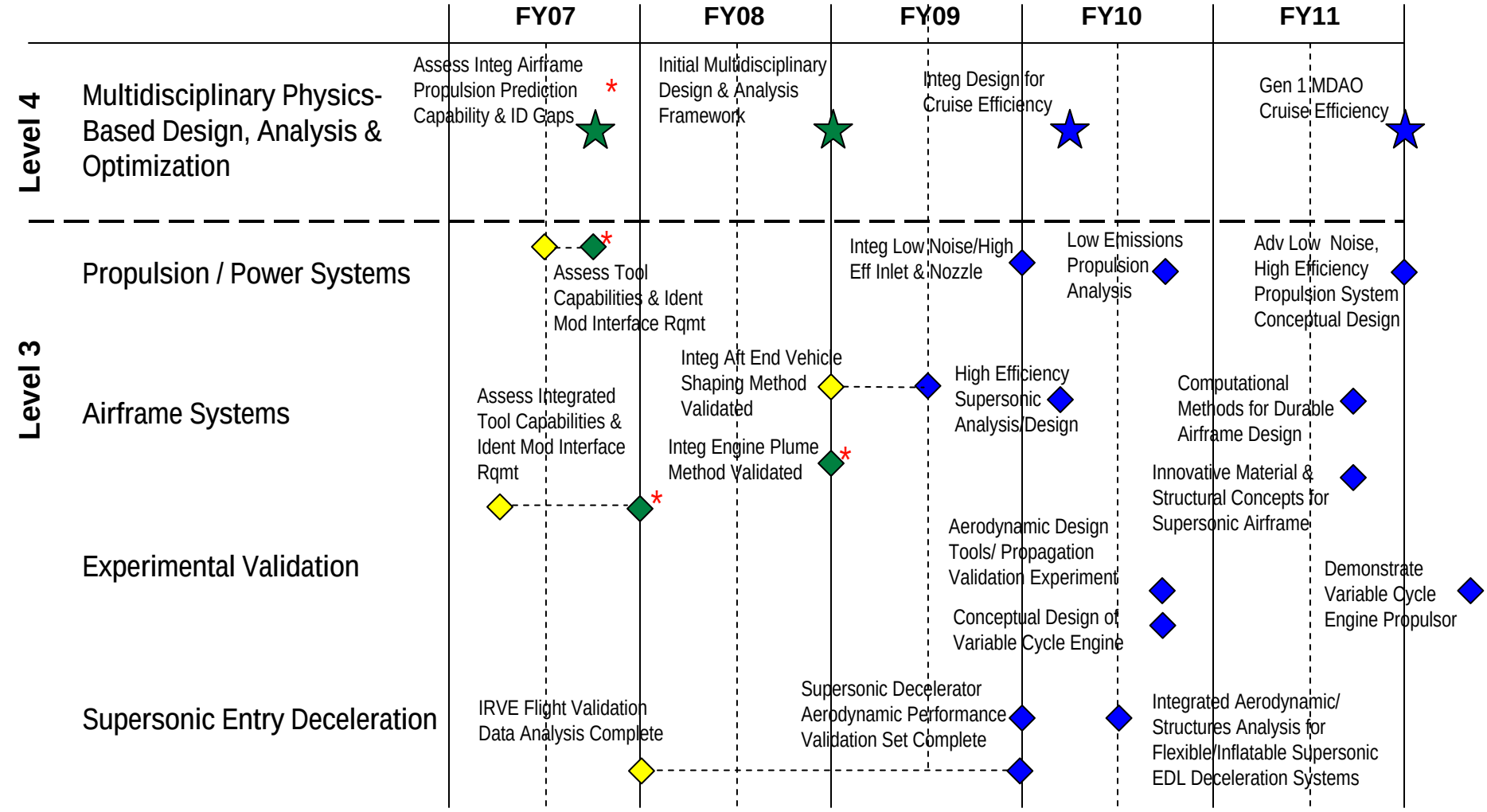
Key:
Principal Investigator (PI), Project Manager (PM), Project Scientist (PS)
Associate Principal Investigator (API); Associate Project Manager (APM)

2. System Integration, Assessment & Validation (SIAV)
3. Supersonic Cruise Efficiency- Propulsion (SCE-P)
4. Supersonics Cruise Efficiency- Airframe (SCE-A)
5. Lightweight and Durable Airframes (LDA)
6. Lightweight and Durable Engines (LDE)
7. Airport Noise (AN)
8. Sonic Boom Modeling (SBM)
9. High Altitude Emissions (HAE)
10. Aero-Propulso-Servo-Elasticity (APSE)
11. Experimental Capabilities (EC)
12. Planetary Entry, Descent, and Landing (EDL)

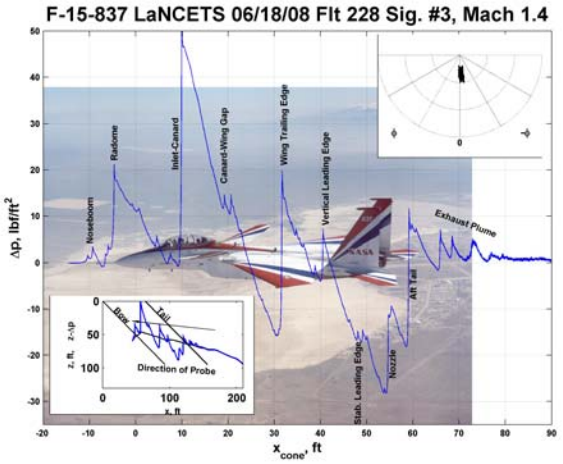
Project Key Milestones



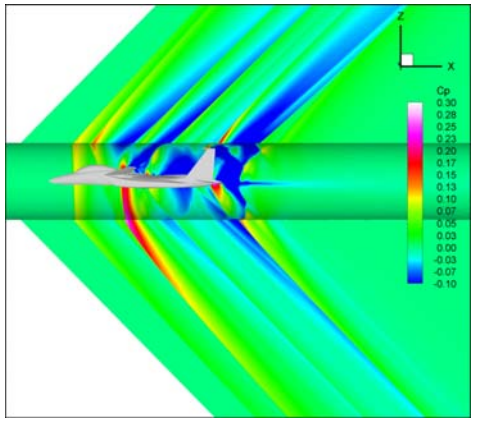
◆ Completed ◇ At risk or Date has Slipped ◆ Planned

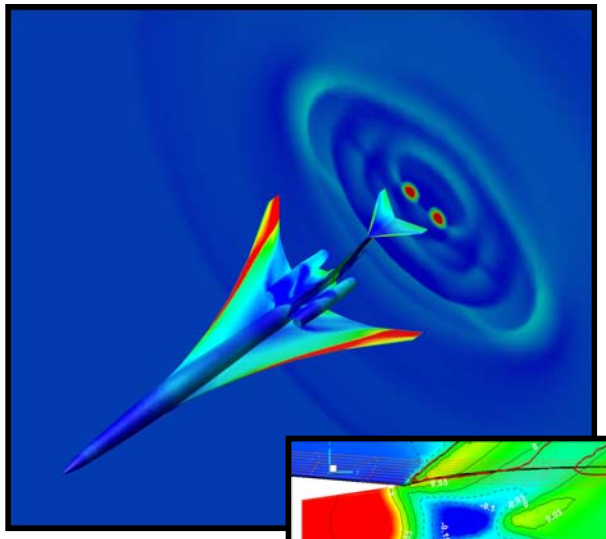
•Supports Annual Performance Goal Milestone

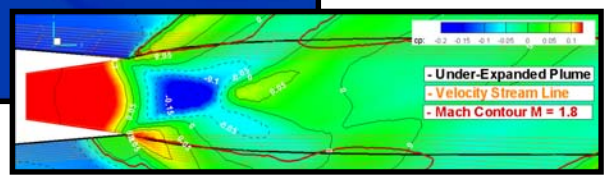
FY 2008 Highlights: Systems Integration, Assessment and Validation



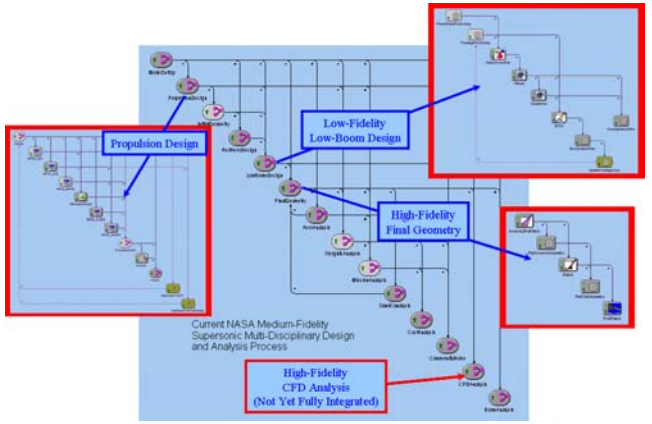
Lift And Nozzle Change Effects on Tail Shock - LaNCETS



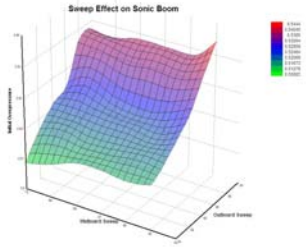




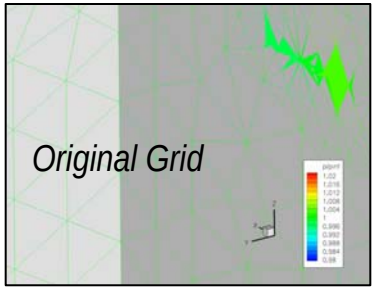
Integrated Engine Plume Methodology Validated Analytically

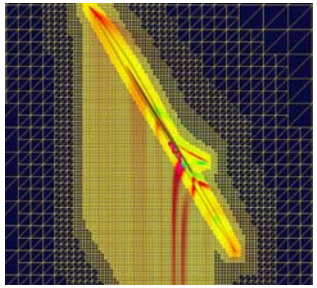


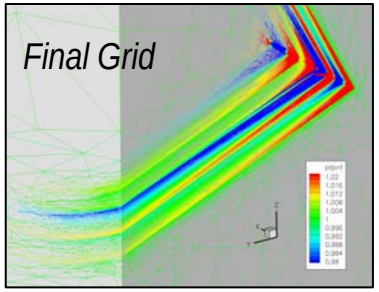
Initial Supersonics Multidisciplinary Design & Analysis Framework

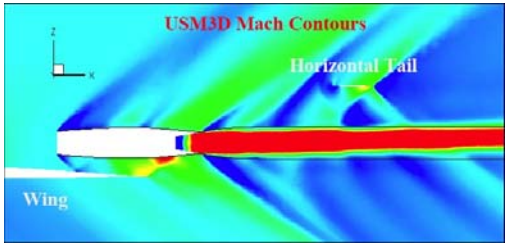


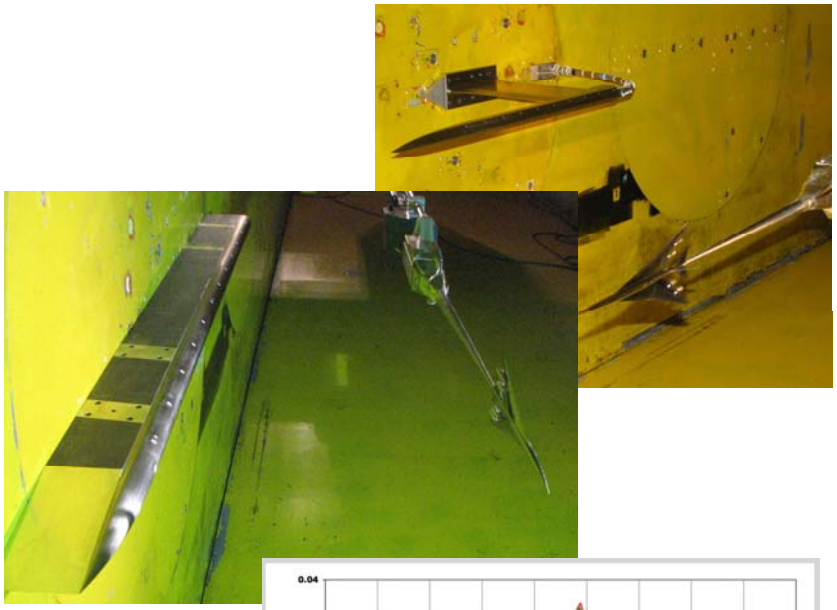
FY 2008 Highlights: Cruise Efficiency

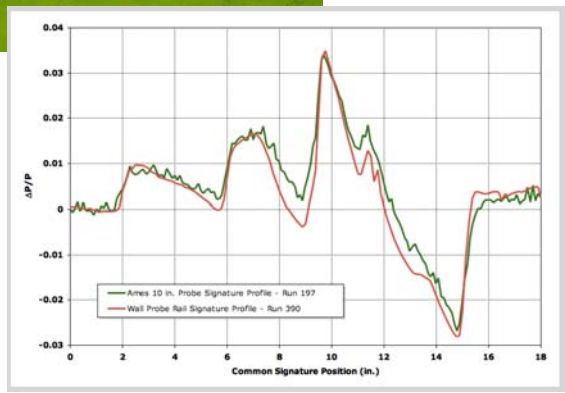


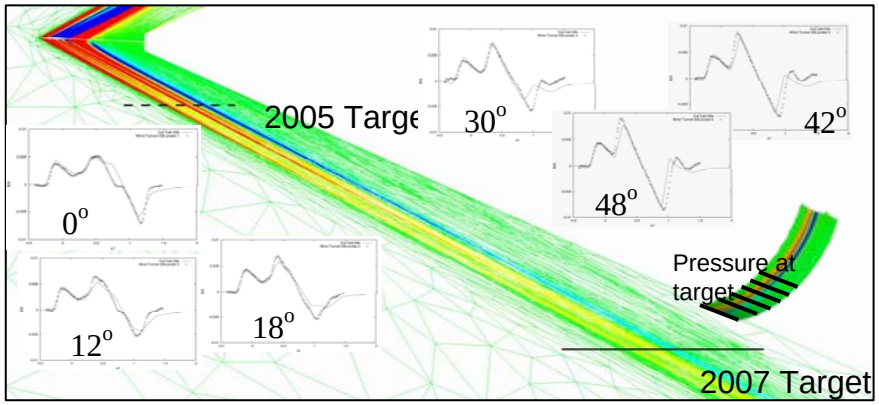










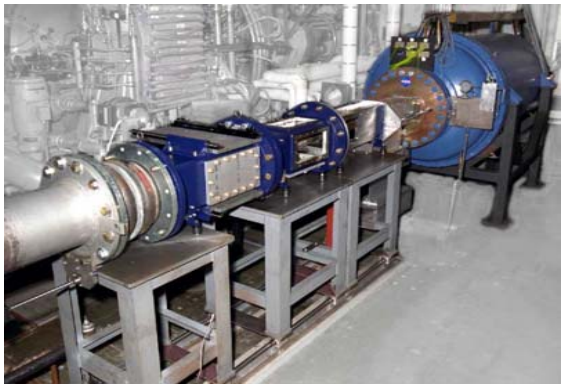


Improved CFD Techniques for Prediction of Sonic Boom and Cruise Efficiency

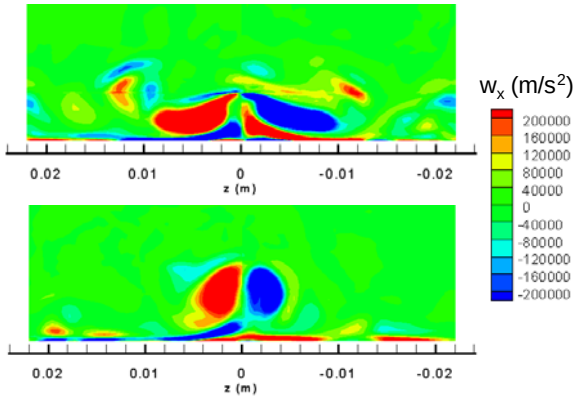
Improved techniques for off body flow field pressure measurement demonstrated in 9x7 UPWT tunnel

FY2008 Highlights: Cruise Efficiency

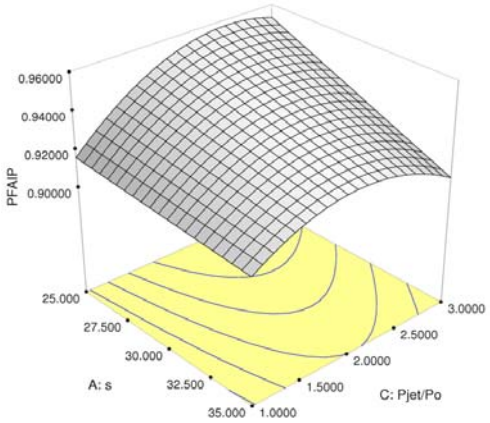
Low-Boom Inlet Development Enabled Through Micro Ramp Flow Control



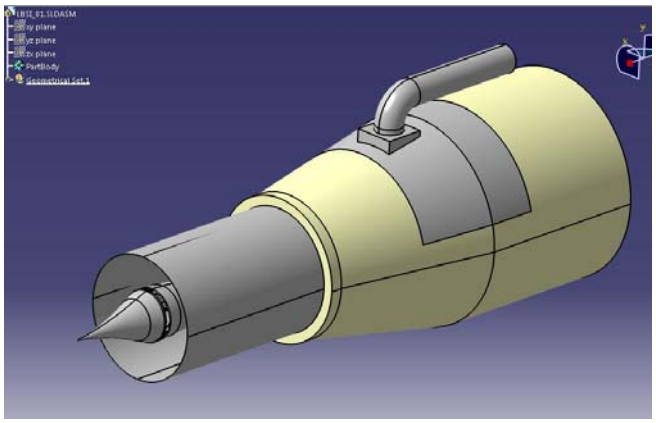
Fundamental Experiments



Large-Eddy Simulation, NRA U. Illinois



Design of Experiments Optimization

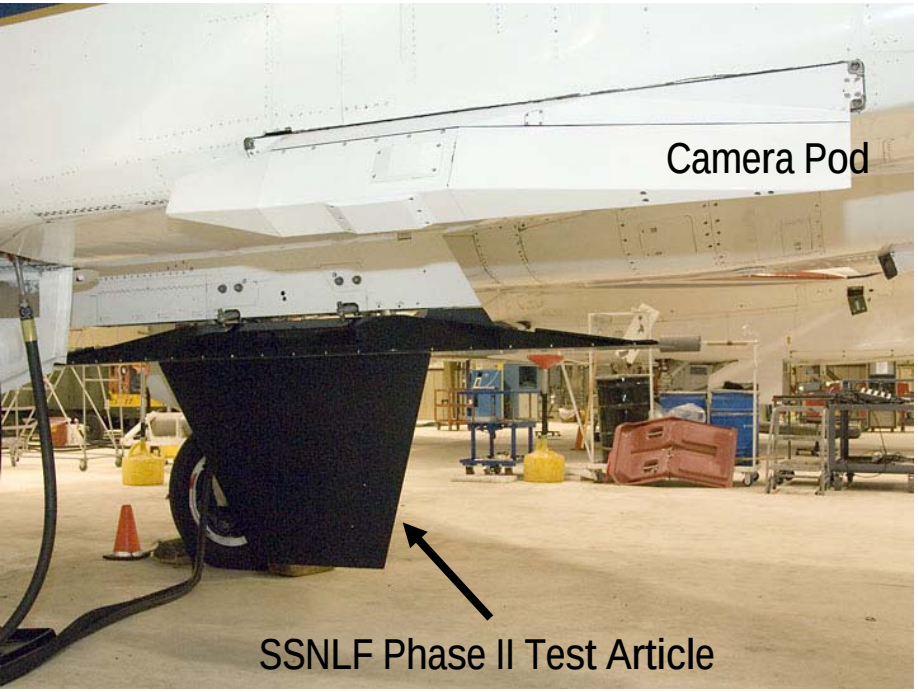


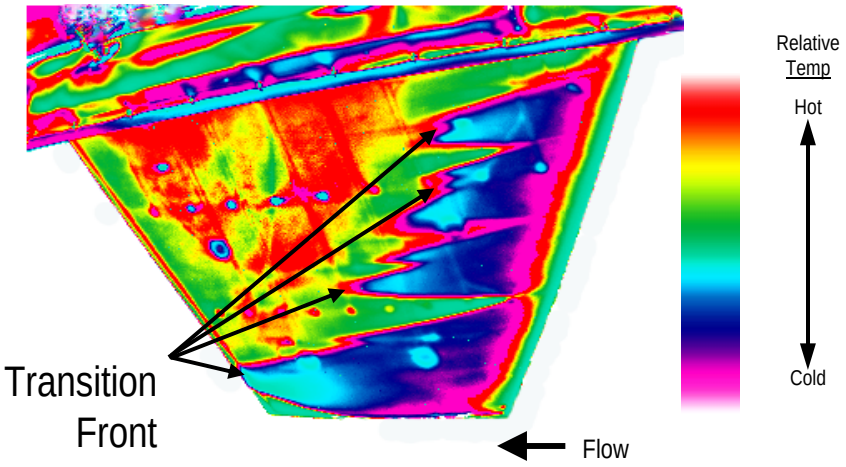
Large-Scale Inlet Design, NRA U. Ill & Gulfstream

FY 2008 Highlights: Experimental Capabilities

Developed and flight validated improved digital infrared research system on F-15B

- New IR camera and digital recorder
- For use on large Reynolds number supersonic transition test in FY2009
- Early data on leading edge sensitivity

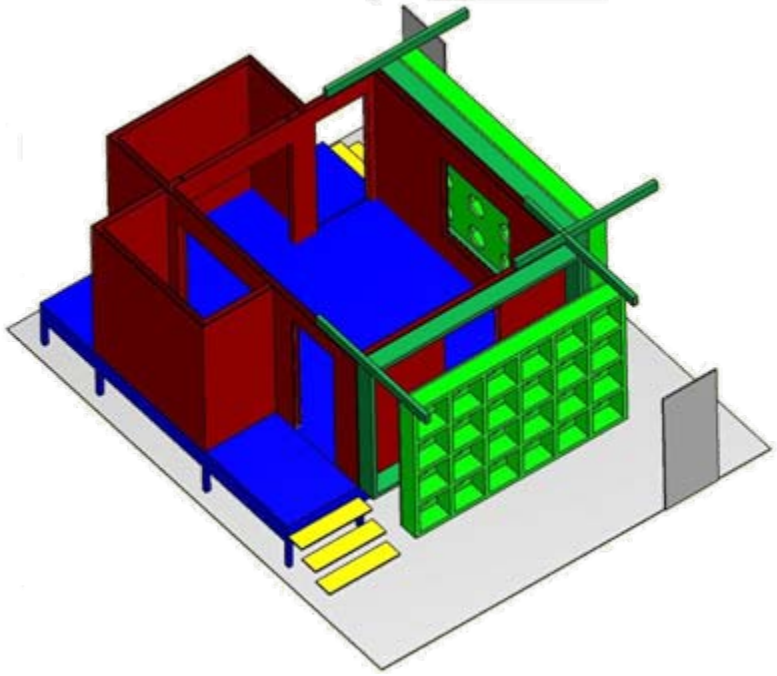




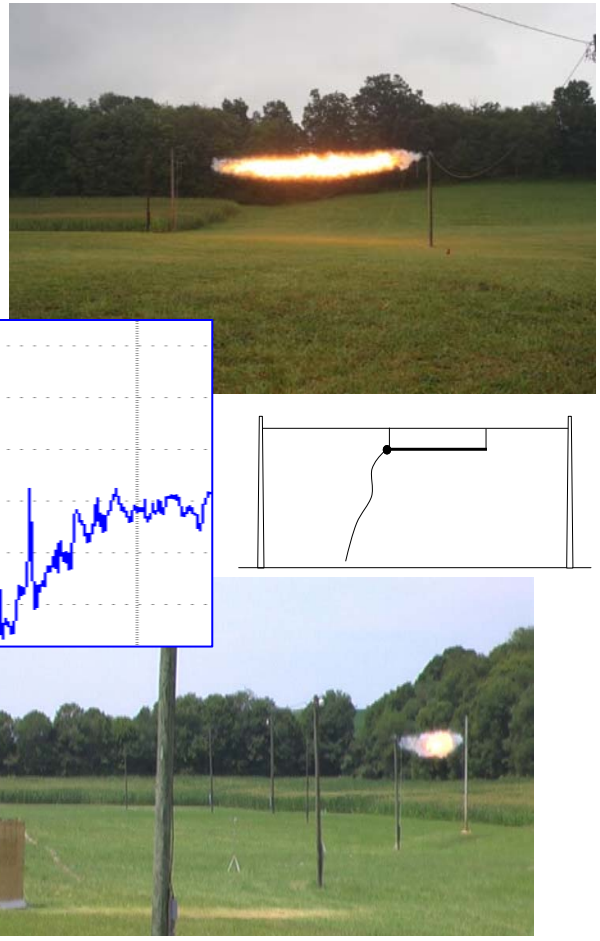
False color digital IR image, M~1.72

FY 2008 Highlights: Sonic Boom Modeling

Goals for 2009: indoor sonic boom simulator up and running.
Validated low frequency building response/transmission model
Updated boom propagation code



Completed design of sonic boom simulator for studying human response to booms heard indoors. Construction scheduled to be complete in February 2009.

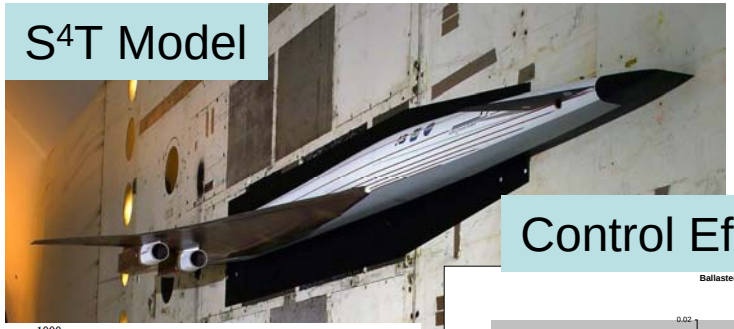


NRA with VPI studying response of structures to sonic boom-type stimuli using linear charge

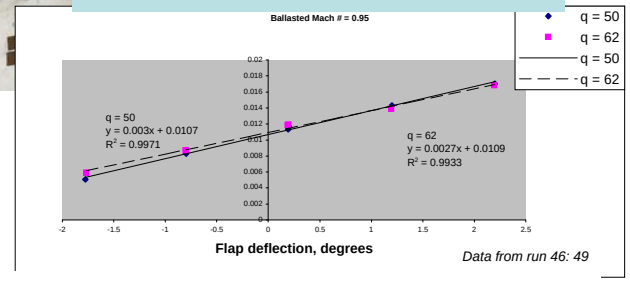
FY 2008 Highlights: AeroPropulsoServoElasticity

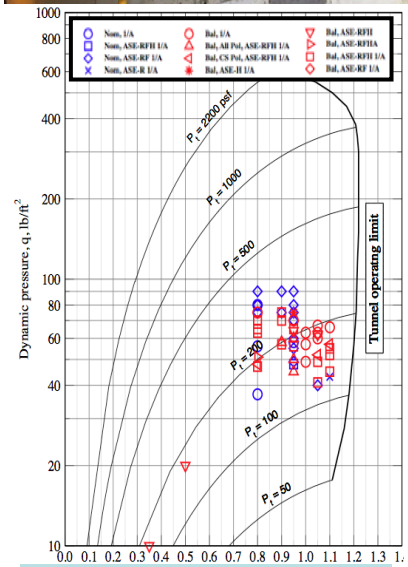
2nd Open-Loop Test Completed

S4T Model

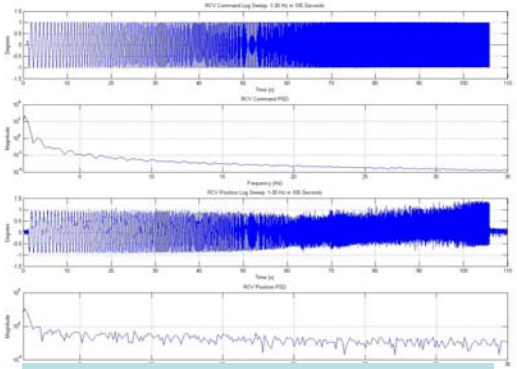


Control Effectiveness





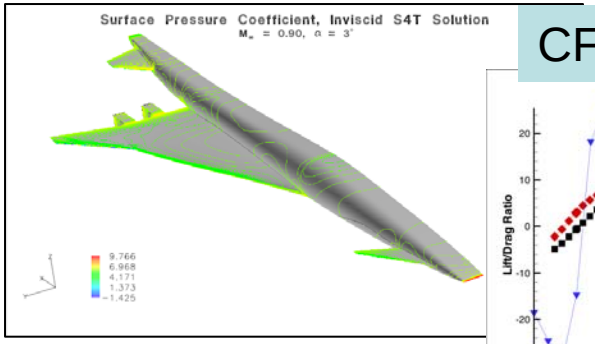
Test Conditions

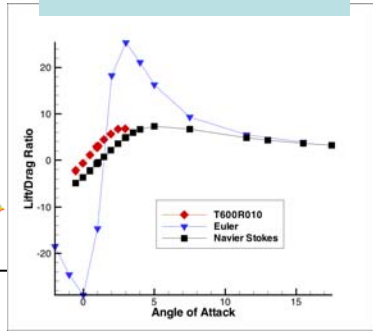


Actuator Responses

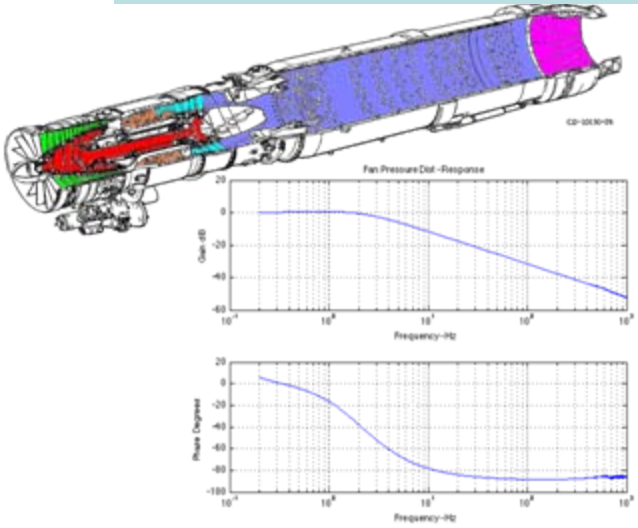
CFD and Engine Models Underway

CFD Results

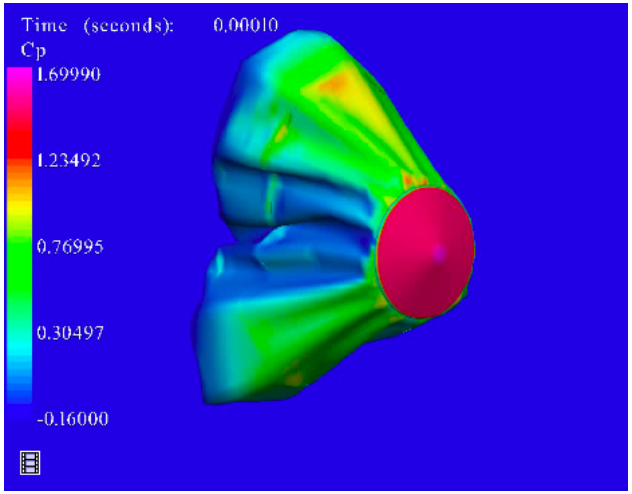




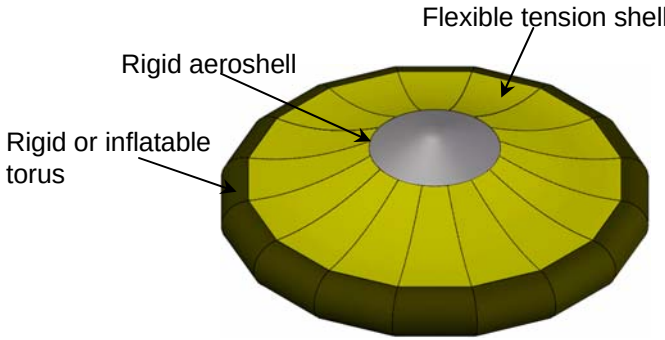
Dynamic Engine Models

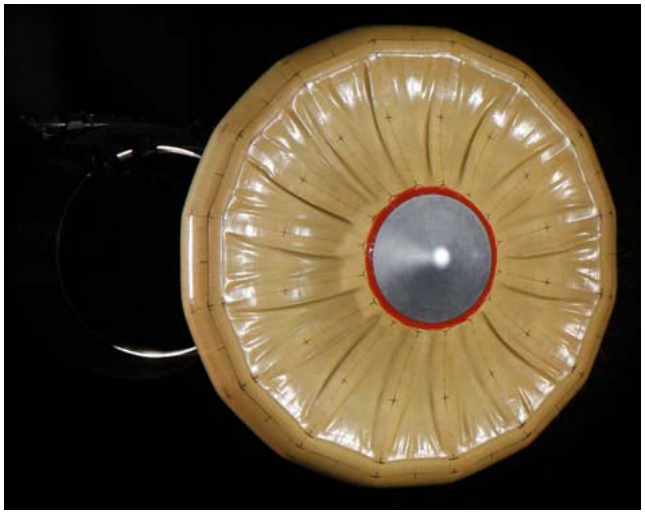


FY 2008 Highlights: Supersonic EDL

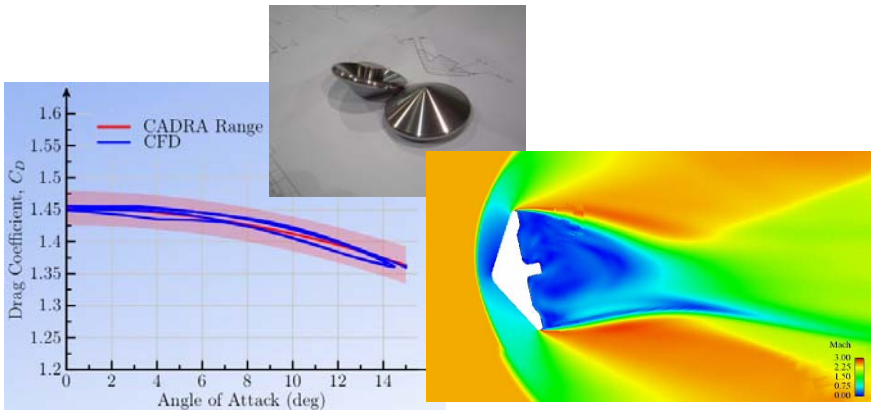


Computational FSI



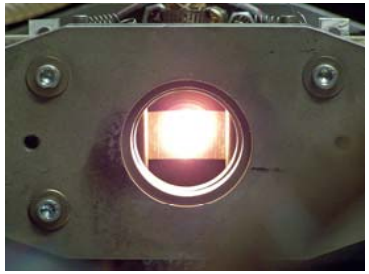


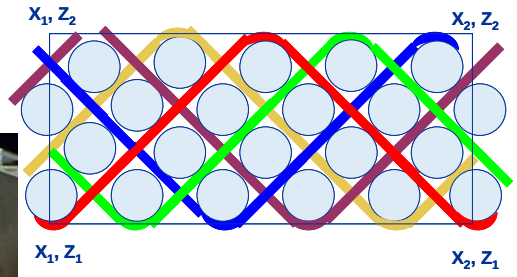
Extensive Wind Tunnel tests of Tension Cone Decelerator, including inflation



Experimental and Analytical Assessment of Performance

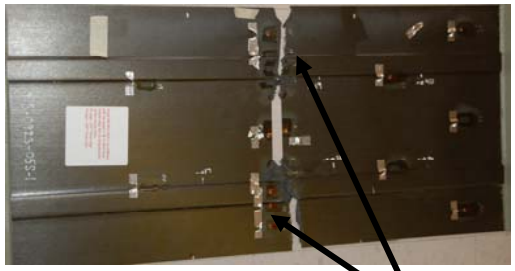
Highlights: Lightweight and Durable Airframes and Engines

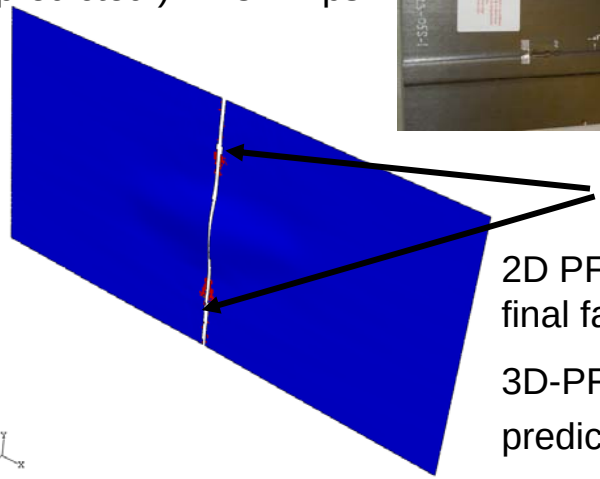




Demonstrate feasibility for producing supersonic CMC turbine blades, 3D reinforced with SiC fibers

Final failure load
(measured) = 46.3 kips
(predicted) = 43.7 kips





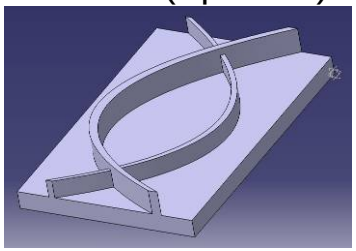
Self-Similar Crack

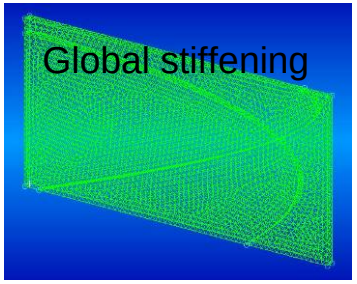
2D PFA under predicted final failure load.

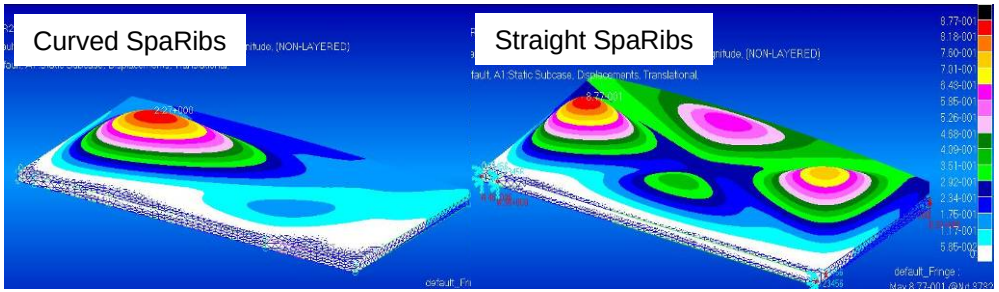
3D-PFA required to predict final failure load.

Progress in progressive failure analysis

Curvilinear Spars and Ribs (SpaRibs)







Combined Material/structures solution for curvilinear stiffeners enables control of buckling.

NRA Awards

Technical Challenge	NRA Awards	
	Educational Institutions	Commercial Entities
Systems Integration & Assessment	2	6
Cruise Efficiency - Propulsion	3	2
Cruise Efficiency - Airframe	4	1
Lightweight & Durable Airframes	6	1
Lightweight & Durable Engines	8	1
Airport Noise	5	2
Sonic Boom Modeling	2	3
High Altitude Emissions	5	2
Aero-Propulso-Servo-Elasticity	0	2
Experimental Validations & Capabilties	0	1
Entry, Decent, & Landing	5	4
Total Awards	40	25

Total: 65 NRA Awards - $32.3M

Key Cooperative Partnerships

- Gulfstream Aerospace
  - Tool development and validation for integrated low boom/low drag aircraft design
  - External Vision System requirements validation
- Aerion Corporation
  - Supersonic Boundary layer transition prediction and validation using the CLIP test fixture on F15B
- U.S. Air Force
  - Propulsion cycle study and optimization for mixed mission variable cycle engines
  - Micro ramp flow control
- DARPA Supersonic Oblique Flying Wing (through August 2008)
  - Technical analysis and guidance as members of Government Team
- General Electric
  - Low emissions combustor testing
- Rolls Royce North America
  - Ceramic propulsion components
- Japan Aerospace Exploration Agency
  - Modeling of sonic boom transmission and indoor exposure

We welcome discussion on Future Partnerships

Supersonic Technical Sessions

- Tuesday PM
  - Systems Integration, Assessment and Validation
  - Aero-Propulso-Servo-Elasticity
- Tuesday PM (Parallel Session)
  - N+3 Concept Studies Kick off (Supersonics @ 4:00pm)
- Wednesday AM
  - Light Weight and Durable Airframes & Engines
  - Airport Noise
- Wednesday AM (Parallel Session)
  - Sonic Boom Prediction Workshop
- Wednesday PM
  - Airport Noise (cont'd)
  - High Altitude Emissions
  - Sonic Boom Modeling
- Thursday AM
  - Entry Descent and Landing (Joint session with Hypersonics)
- Thursday PM
  - Feedback Session (Open forum 30 minutes)
  - Supersonic Cruise Efficiency - Propulsion & Airframe
  - Experimental Capabilities

Thank You,

Welcome to the 2008 Fundamental Aeronautics Annual Meeting

Next Speaker:

Dr. Jim Pittman: Principal Investigator, Hypersonics Project